

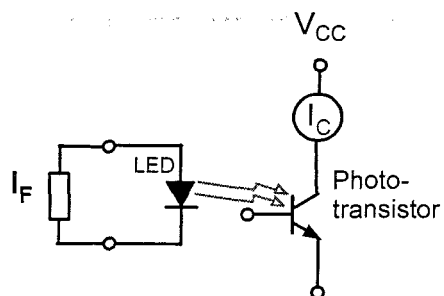
Proton Damage in Optocouplers

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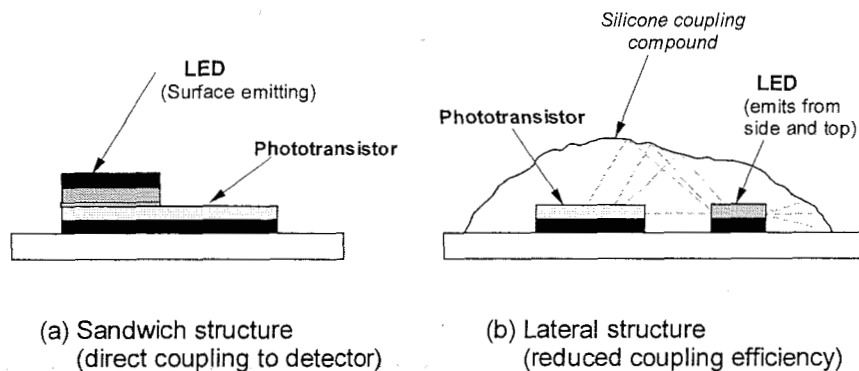
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Basic Properties of Optocouplers



$$\text{Current Transfer Ratio} = \frac{I_C}{I_F}$$

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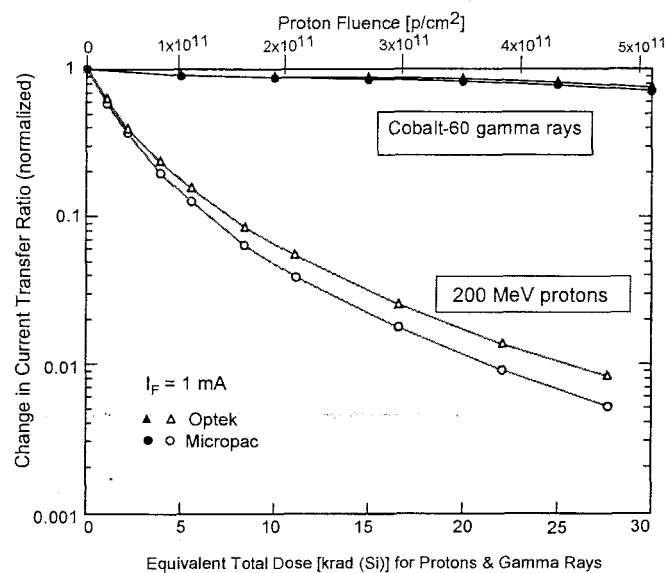
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- Basic optocoupler with $CTR_{min} = 2$
- Extremely sensitive to proton displacement damage effects
- Caused by amphoterically doped LED technology

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- High speed optocoupler with digital output; $CTR_{min} = 10$
- Uses different LED technology that eliminates extreme sensitivity to proton damage
- Sensitive to transients from protons and heavy ions
- Requires standby power for digital circuitry

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Issues

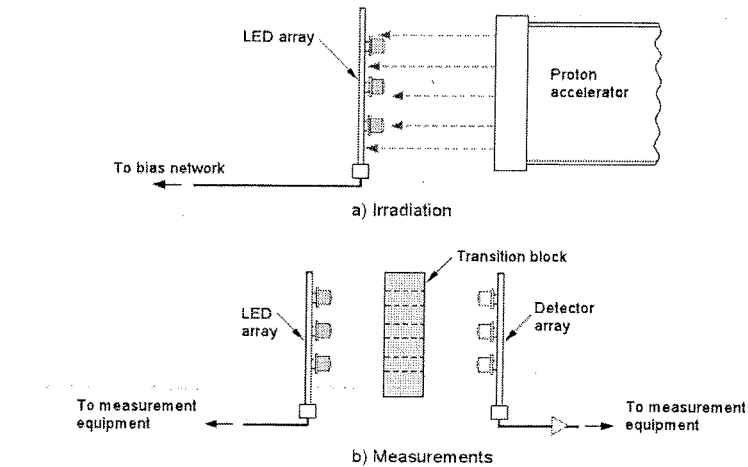
- Proton energy and energy loss in package
- Bias conditions during testing
- Test parameters
- Annealing of damage after irradiation

Other Factors

- Circuit applications
- Unit-to-unit variability

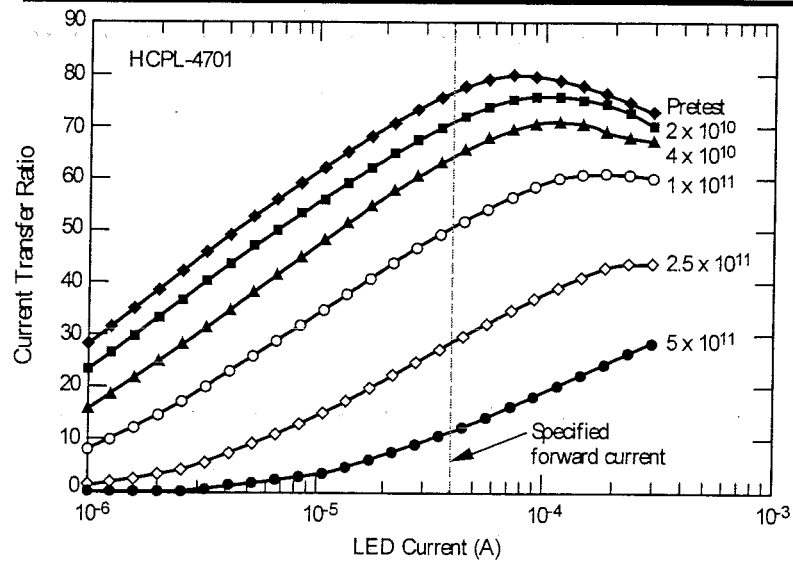
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Diagram of Proton Tests of Discrete LEDs

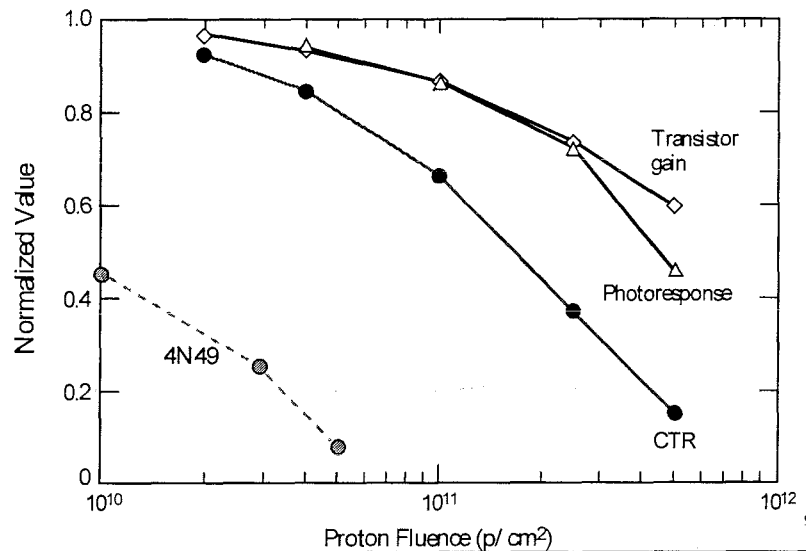


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Degradation of HCPL-4701 Optocoupler



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Proton Energy Is Important

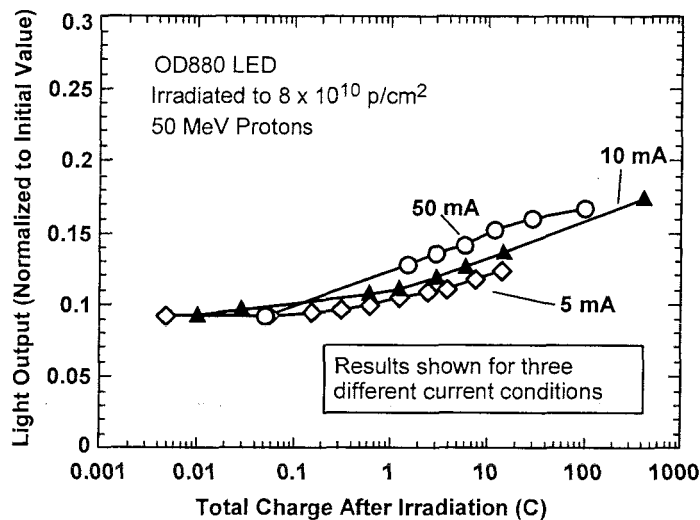
- Non-ionizing energy loss is uncertain for energies above 65 MeV
- Tests at energies below 65 MeV are recommended
 - Near peak in energy spectrum for most systems (after shielding)
 - Tests at high energies introduce errors in interpretation
 - Displacement in silicon and III-V elements can contribute to degradation
- Damage needs to be related to energy spectrum in application

Annealing Is a Potential Interference for Optocoupler Testing

- Biasing devices for extended periods prior to and after irradiation will markedly reduce the measured damage
- Injected current during measurements can also cause significant recovery

Optocouplers Are Hybrid Devices

- Particularly affected by LED technology
- No explicit control over LEDs in device specifications



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Optocouplers Are also Sensitive to Transients

- Problem is more severe for devices with high-speed amplifiers
- Caused upsets in Hubble Space Telescope

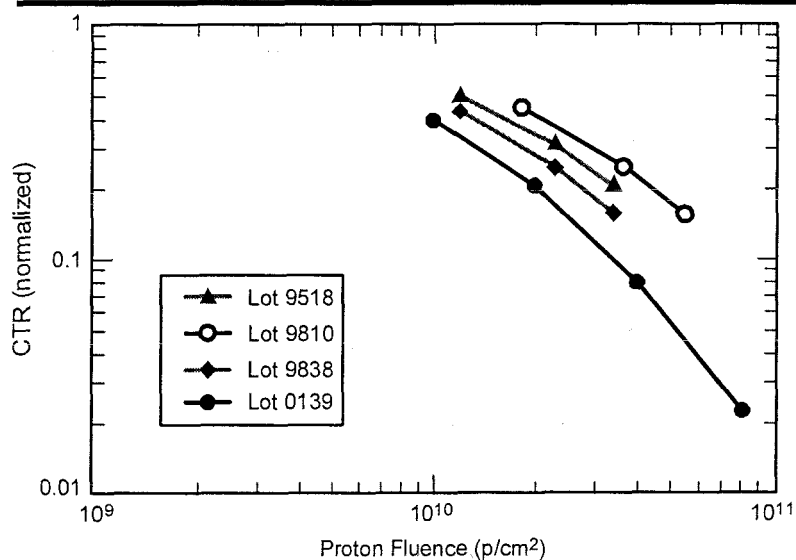
Aging and Temperature Effects Must Be Included

Possibility of Degradation in Coupling Material

Damage in LEDs Is Superlinear with Fluence

- Must be taken into account in interpreting radiation data
- Affects design margins
- "Amplifies" degradation in devices with low initial CTR

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Optocouplers Are Widely Used in Space Systems

- Radiation testing must include tests with high-energy protons
- Some devices are extremely sensitive to proton damage
- New types of optocouplers are available that are much less affected by radiation compared to older optocoupler types

Testing Is More Complex than for Conventional Electronic Devices

- Strong energy dependence of proton damage
- Interference from annealing during irradiation or measurements
- Wider variability in responses because of mechanical issues with optical path

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